Hearing Protection and Noise Workshop

Franklin C. Froman MS, CCC/A
USACHPPMEUR

PHYSICS OF SOUND

What is “Sound”?

- The sensation resulting from stimulation of the auditory mechanism by air waves or vibration

Then, What is Noise?

- Any unwanted sound; varies from person to person!

Requirements For Sound…

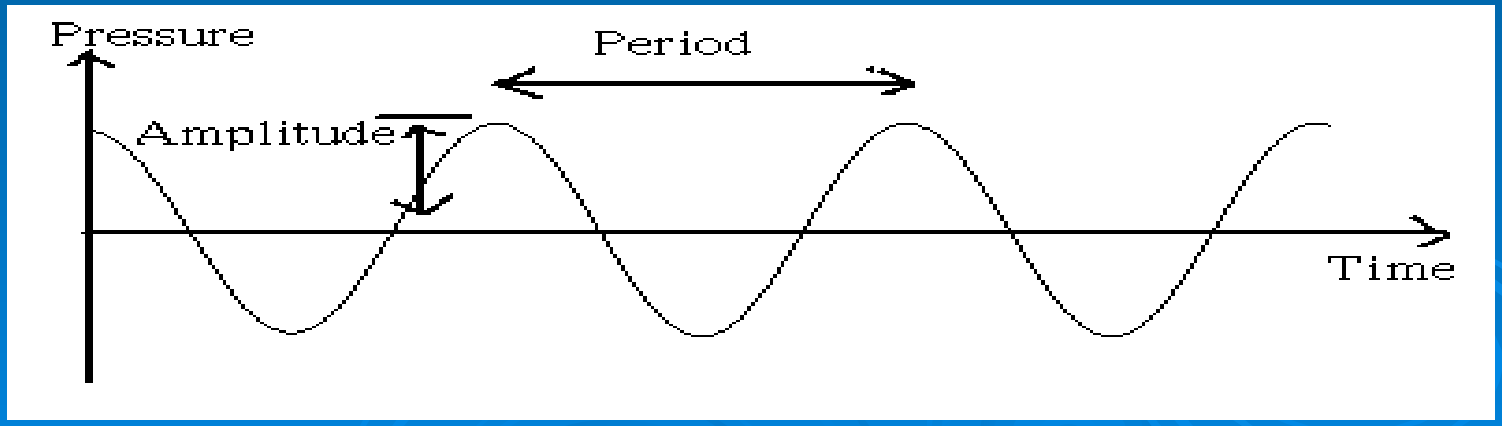
- Source of vibration
- Source of energy
- A medium
- A receiver

Transmission of Sound

- Alternating pressure changes
  - Rarefaction
  - Compression
- Sound Wave
  - series of compressions and rarefactions
- Speed of Sound
  - depends on the medium

The Sine Wave

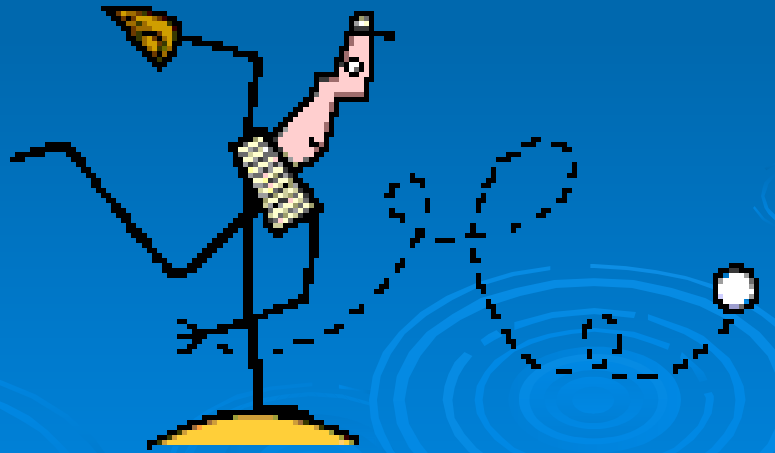
- **Horizontal Axis**: ***time in seconds***
- **Vertical Axis**: ***molecular movement***
- **Compression**: ***upward movement***
- **Rarefaction**: ***downward movement***



FREQUENCY

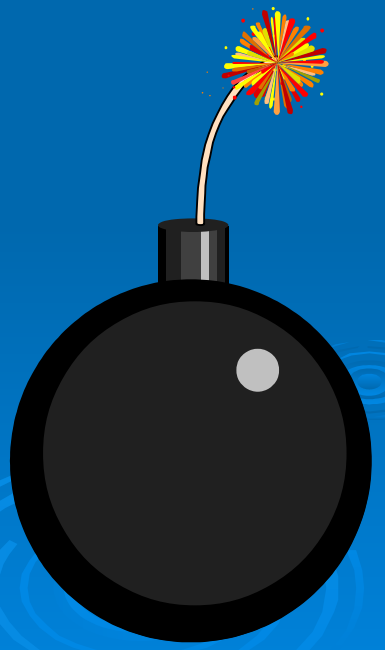
- Perceived as "Pitch"
- Equal to the number of complete cycles that occur in one second
  - one cycle is equal to one compression and one rarefaction.
- Measured in Hertz (Hz)
- Human range: 20-20,000 Hz

- Human ear is most sensitive in the 1,000 to 4,000 Hz range.
- Least sensitive to lower frequencies



Intensity

- Perceived as "Loudness"
- Pressure produced by the movement of the molecules; sound pressure level(SPL)
- Amplitude (height of the wave) shows the pressure intensity level
- Measured in decibels(dB)
  - 1/10 of a bel, or .0002 dynes/cm2 SPL
- Decibels are logarithmic units
- Intensity range for humans= 0 to 140 dB



INVERSE SQUARE LAW

- DOUBLING THE DISTANCE FROM THE SOUND SOURCE DECREASES INTENSITY BY 6dB

Duration

- Perceived as "Time"
- can last from thousandths of a second, to several hours, to all day!

Spectrum

- Perceived as the "Quality" of sound
- Varies from a simple puretone to a complex mix of many frequencies and intensities; such as the human voice!

Hazardous Noise

- Continuous noise (longer than .5 seconds) greater than 84 dBA
- Impulse/Impact noise greater than 140 dB peak SPL
  - explosions
  - weapons fire
  - two or more objects hitting together
  - *Intensity and duration are the two main factors that determine if a particular noise is hazardous*

Sensitivity of the Human Ear (Review)

- Frequency Range: 20 - 20,000 Hz
- Intensity Range: 0 - 140 dB (approximate as young people can hear in negative numbers, and above 140 dB is very painful)
- Speech Frequencies: 500 - 4000 Hz (there are speech sounds in lower and higher frequencies, but the human ear hears speech in these frequencies best)
  - Consonant Sounds - soft, low energy, high frequency sounds
  - Vowel Sounds - loud, high energy, low frequency sounds

ANY QUESTIONS?

Personal Hearing Protective Devices

Hearing Protector Types

All Army-issued hearing protective devices must have Office of The Surgeon General approval

Earplugs

a. **Non-Standard**

   Bi-digital (fingers)

   Palm of hand

b. **Pre-formed**

   Must be medically fit by qualified technicians

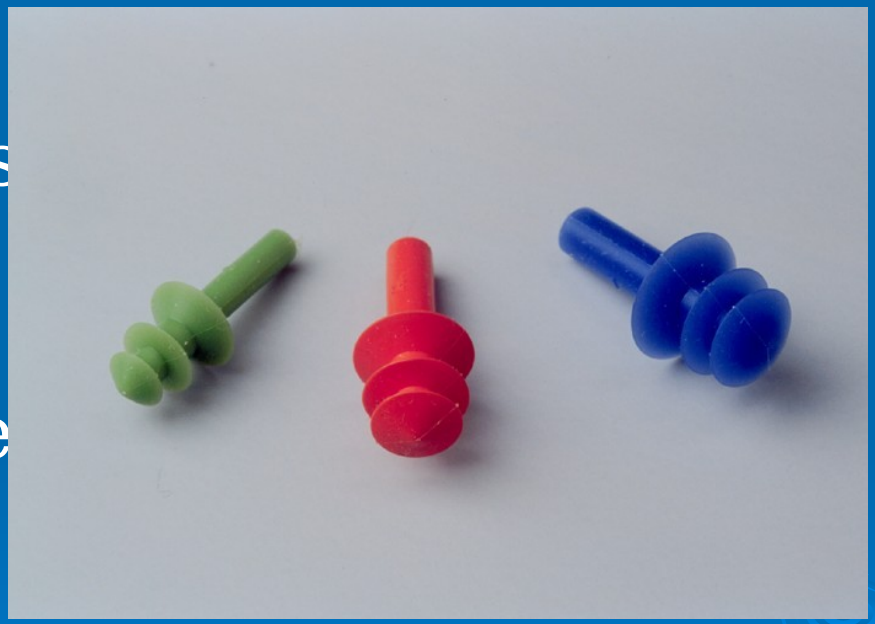
   Both ears must be individually sized and

Hearing Protector Types (TF)

(1)Triple-Flange

3 color-coded sizes

* Small (green)
* Medium (orange
* Large (blue)



Hearing Protector Types (cont.)

A carrying case with an insertion tool inside is provided with each set of pre-formed earplugs issued.

Hearing Protector Types (TF)

Triple-Flange Fitting Technique Using Insertion Device

* Place stem of plug into holder
* Insert plug into canal and gently twist
* First two flanges are inside the canal
* Third flange lies flush against the canal entrance
* Tension on the stem of plug
* Only one hand needed for appropriate fit

Hearing Protector Types (TF)

Triple-Flange Fitting Technique Using Opposite Hand

* Pull the ear up (or out) and
* Insert plug into the canal a twis
* Fit both ears!

Hearing Protector Types (SF)

(2) Single-Flange

5 color-coded sizes

* X-Small (white)

* Small (green)

* Medium (orange)

* Large (blue)

Pre-Formed Earplug Sizing Distributions

* Persons who are younger, female and blacks tend to require smaller earplug sizes

* Persons who are older, male and whites tend to require larger earplug sizes

* Those who require a different plug size in each ear:

  Triple-Flange (1–2 %)

  Single-Flange (5–8 %)

Care & Maintenance Pre-Formed Earplugs

* Clean after each use with warm, soapy water
* Dry well before storing
* Check annually for correct size and deterioration
* When unserviceable, discard and get refitted

Hearing Protector Types (Foam)

(3)Hand-formed Foam (yellow or white polyvinyl chloride)

* Universal (one size fits most)
* Store in earplug ca
  or com

Hearing Protector Types (Foam)

Fitting Techniques

* Roll into a crease-free cylinder (thumb/index finger)
* Insert 2/3 of plug into canal
* Hold plug in place with finger until fully expanded
* Plug will keep its shape even after being removed

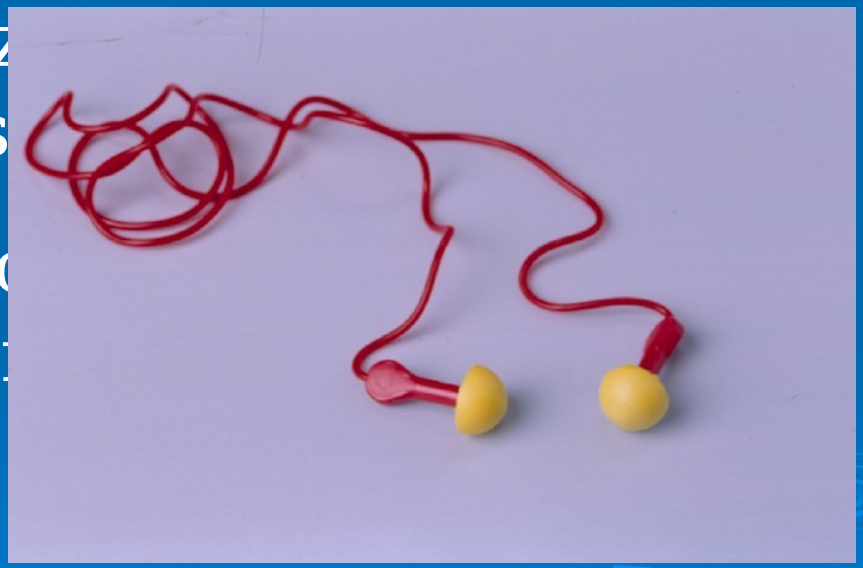
Care and Maintenance Handformed Earplugs

* Their acoustic properties change when washed
* Discard after one or two uses

Hearing Protector Types (Pod)

(4)Pod Foam (Corded and Uncorded)

* Universal (one siz
fits mos
* Store in military c
or comi



Hearing Protector Types (CA)

(5)Combat Arms

* Newest author
earplu

* Currently avai
in only
(medium/large)

* A double-tree design for use as both a linear and non-linear plu

* Or single Combat Only

Hearing Protector Types (CA)

Combat Arms (Steady-State Noise Exposure)

* One end has a solid (linear), olive drab tip for use in steady-state noise conditions (e.g., helicopters, armored personnel carriers)

* The olive drab portion is inserted into the canal

* The bright yellow portion is exposed and aids in the monitoring of the plug's use

Hearing Protector Types (CA)

Combat Arms (Impulse Noise Exposure)

- The other end is non-linear, yellow in color and has a small, calibrated hole that must be kept clean and free of wax.
- There is a second, calibrated hole in the earplug stem that dampens hazardous, high frequency components of impulse noise.
- As a non-linear device, it aids speech communication in the presence of impulse noise with the help of a small filter in the

Hearing Protector Types (CA)

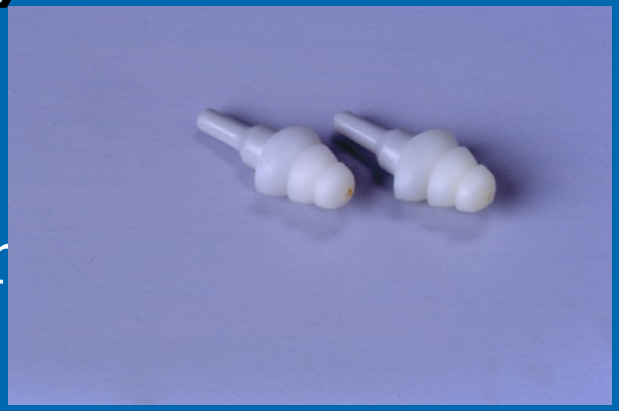
Combat Arms Advantages

* Relatively inexpensive for its potential benefits

* Easy to maintain

* Compatible with head gear (e.g., helmets)

Hearing Protector Types (Other)



(6) Other (Musician's)

* Designed for musician sound engineers

* Can be worn comfortably for long periods

* Sound is attenuated by specialized filters

* Equal level of protection at most frequencies

Hearing Protector Types

Noise Muffs (Circumaural Protector)

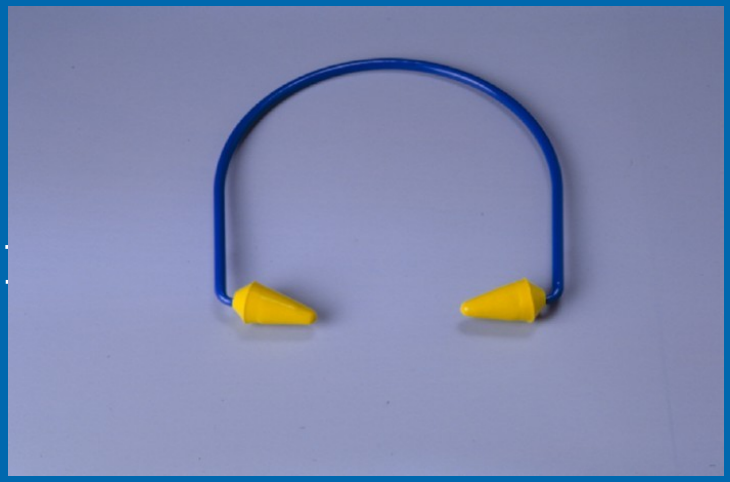
* Universal – one size f
  most
* Fitting techniques
  - Ear-cups must totally
    seal and enclose each ear
  - Adjust headband for firm, comfortable fit
  - Headband placement options vary

Care and Maintenance Noise Muffs

* Wipe ear-cup seals with moist cloth
* Check seals regularly & replace if damaged
* Replace foam cushion inserts when deteriorated
* Check for cracks or holes in ear-cups
* Ensure for adequate headband tension
* Never modify this equipment

Hearing Protector Types

Ear Canal Caps



* Universal – one size fits
* Fitting techniques

Insert canal caps as far into the outer ear canal as possible to form an effective seal

Adjust headband for a firm, comfortable fit

Variable headband placement options

Care and Maintenance Ear Canal Caps

* Clean after each use with warm, soapy water
* Dry well before reuse
* When unserviceable, replace

Hearing Protector Types - Helmets

Aviator Helmet

* SPH-4B and HGU-5
* Variable helmet sizes

Combat Vehicle Crewmen (CVC) Helmets

* Limited helmet/liner sizes

Care and Maintenance Helmets

* Check ear-cup seals at least semi-annually
  - Replace cracked or broken seals
* Check CEP ear piece
  - Replace dirty or worn out ear pre-formed plug

Communication Headsets

Combat Vehicle Crewman's Headset

* Helmet liner for Vehicle Intercommunication System (VIS) uses active noise reduction

Communication Ear Plug

* For aviation helmets

Field Artillery Headset

* Noise attenuating headset/microphone
* Communications Aural Protective Systems
  - With or without a microphone
  - With passive or active noise reduction

Selecting Hearing Protection

Criteria

(1) Degree of noise attenuation required to prevent any change of hearing thresholds

(2) The work environment

(3) Advantages and disadvantages

Selecting Hearing Protection (cont.)

* Single hearing protection is required for civilians & soldiers working/visiting in industrial-type operations:

When steady-state noise levels are 85 dBA (regardless of duration) up to 103 dBA TWA

* Double hearing protection is required for civilians & soldiers working/visiting in industrial-type operations:

When steady-state noise levels are 104

Selecting Hearing Protection (cont.)

- For soldiers in training, non-industrial or non-combat scenarios where TWA data are unavailable:

Wear single protection for exposures of 85 – 103 dBA

Wear double protection for exposures of 104 – 108 dBA

Wear double protection & comply with time limits for exposures of 109 – 129 dBA

When levels exceed 129 dBA, TSG approval is

Selecting Hearing Protection (cont.)

- For impulse noise level exposures, hearing protection requirements are weapon-specific. For all other situations:

Hearing protection is optional for exposures less than 140 dBP

Single protection is required for exposures of 140 to 165 dBP

For exposures greater than 165 dBP, but less than curve Z, double hearing protection is required

For exposures that exceed curve Z, TSG must

Noise Reduction Rating

* Represents attenuation levels of hearing protection conducted under laboratory conditions
* Does not accurately reflect “real” field conditions
* Actual attenuation values measured in the field are half of what is listed on commercial packaging
* Factors that compromise performance include:

Noise Reduction Characteristics

Cotton – none

Earplugs – better in lower frequencies

Noise muffs – better in higher frequencies

Most standard protectors – best over 1K Hertz

Sources Of “Leaks” To Inner Ear

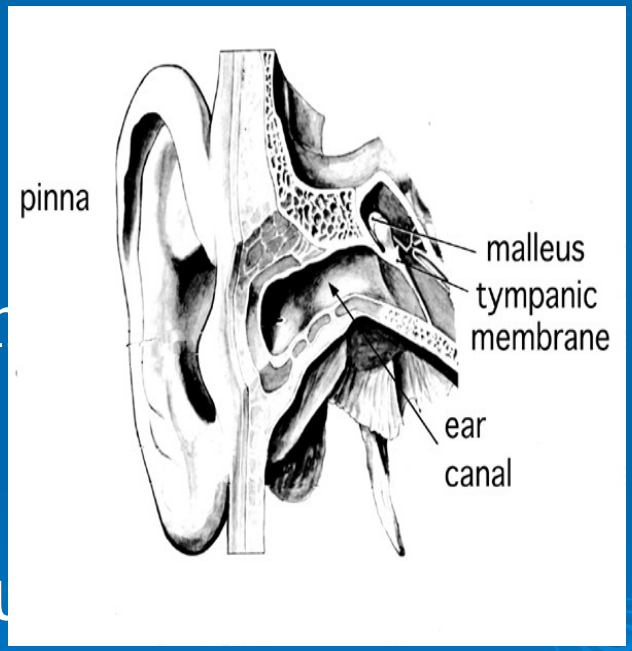
Earplugs

Conventional leaks around th

Piston action of the plug

Transmission through the plu

Transmission through bones/tissues of the head



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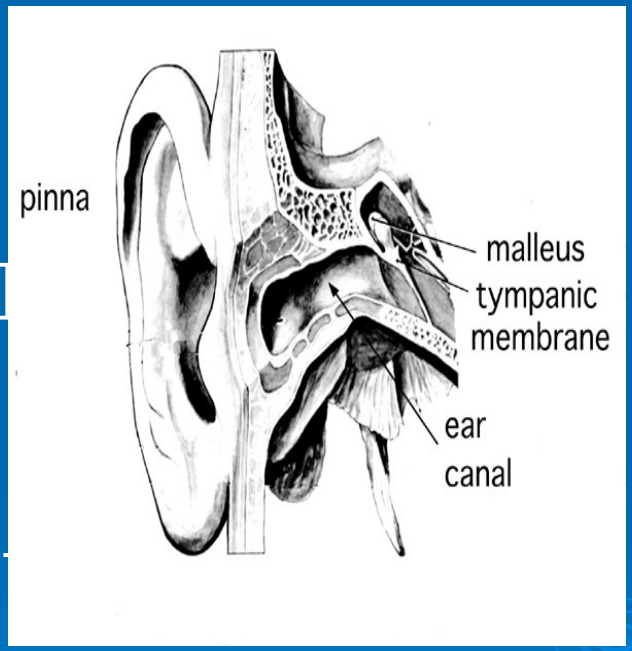


Hearing Protection & Capability

Lombard Effect

Voice level rises in presence of loud background noise in order to monitor one's own speech and to allow others to hear their communication

Occlusion Effect

The person using hearing protection speaks more softly because they hear their own voice via the bone conduction process; voice sounds low-toned; greater awareness of bodily sounds (ringing ears, heartbeat)

Effects on Communication

In Quiet:

Hearing protectors cause reduced speech understanding

With Hearing Loss:

Hearing protectors cause reduced speech discrimination

In Noise with Normal Hearing:

Hearing protectors improve speech discrimination! HP eliminate high frequency noise and allow speech frequencies to pass through

Localization:

With earplugs – no effect when hearing ability

Hearing Performance Factors

For employees who use hearing protection:

(1)The speech of others becomes recognizable in time & with practice in the workplace

(2) Machine noise and its operational characteristics also become recognizable in the same way

(3) Its use is preferable to permanent hearing loss!

Employee Considerations

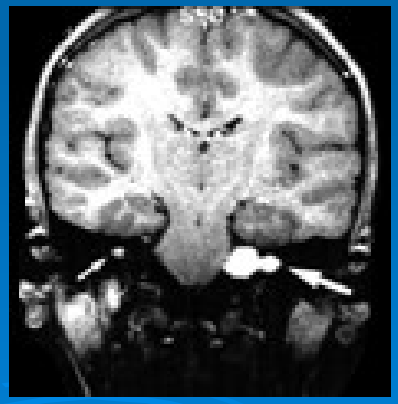
The right to choose from a variety of hearing protectors unless there is a medical or environmental contraindication

The right to receive hearing protection at no cost (gratis)

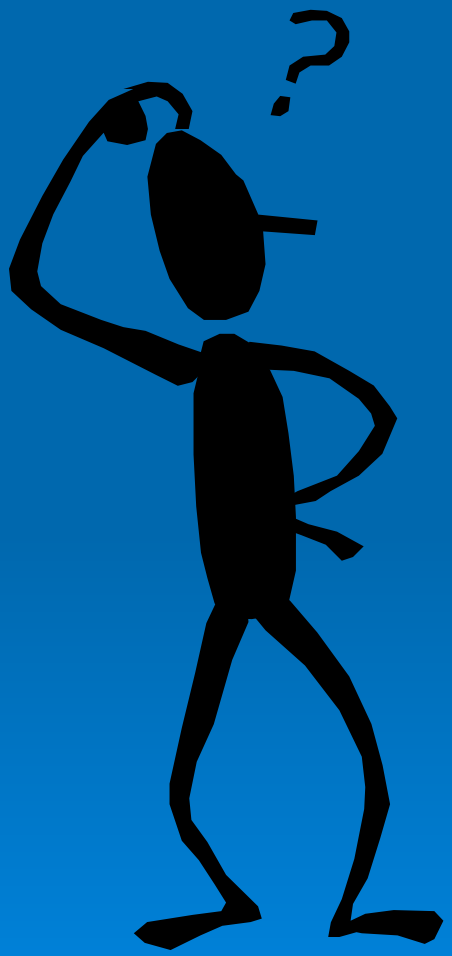
Medically fitted hearing protection – AMEDD funded

Safety items (muffs, helmets, canal caps) – unit funded

EAR DISEASE AND CHARACTERISTICS OF HEARING LOSS



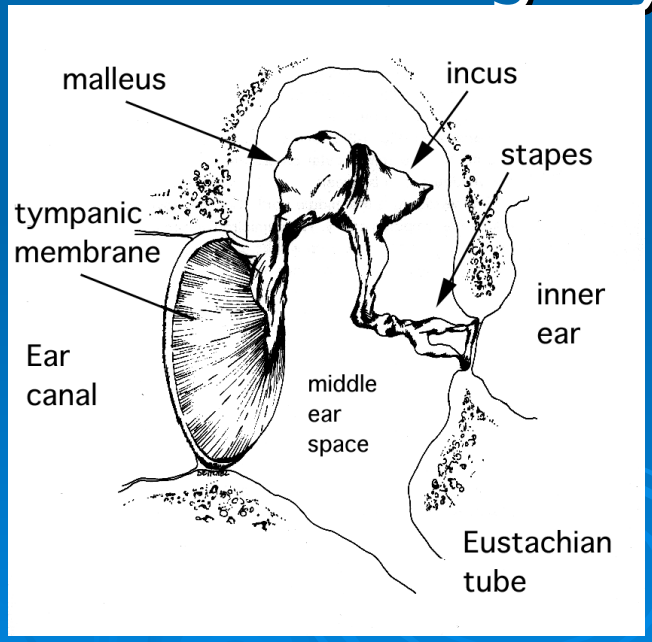
TYPES OF HEARING LOSS:



- CONDUCTIVE
- SENSORI-NEURAL
- MIXED
- NON-ORGANIC

CONDUCTIVE HEARING LOSS

- Occurs from a dysfunction of the outer or middle ear that can usually be treated with medicine or surgery; a deficit of loudness

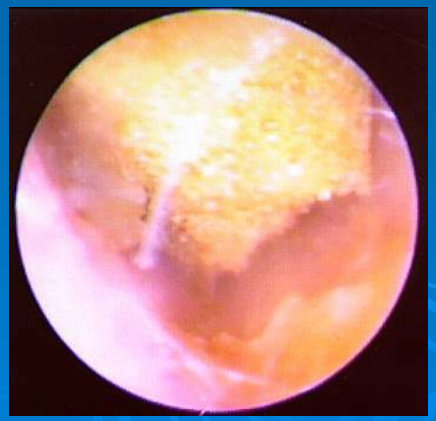


SYMPTOMS:

- Soft speaking voice
- Excellent speech discrimination when speech is loud enough
- Low frequency or flat hearing loss (equal at all frequencies)

CAUSES OF CONDUCTIVE HEARING LOSSES:

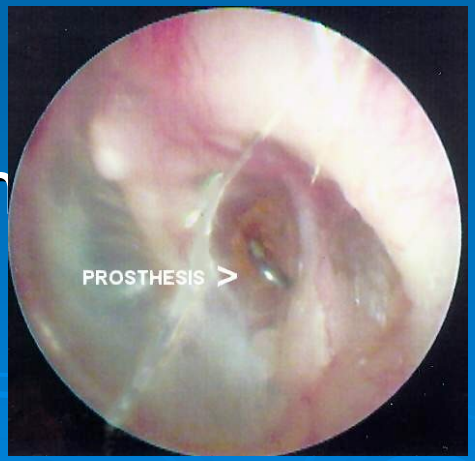
- Outer Ear:
  - Occlusion
  - Congenital Atresia
  - External Otitis



Photo's courtesy of Dr. Roy F. Sullivan, Ph.D.

Causes of Conductive Hearing Loss: Middle Ear

- Otitis Media
- TM Perf.
- Cholesteatoma
- Otosclerosis
- Ossicular Disarticulation
- Blocked Eustachian Tube



Photo's courtesy of Dr. Roy F. Sullivan, Ph.D.

TREATMENT: CONDUCTIVE HEARING LOSSES

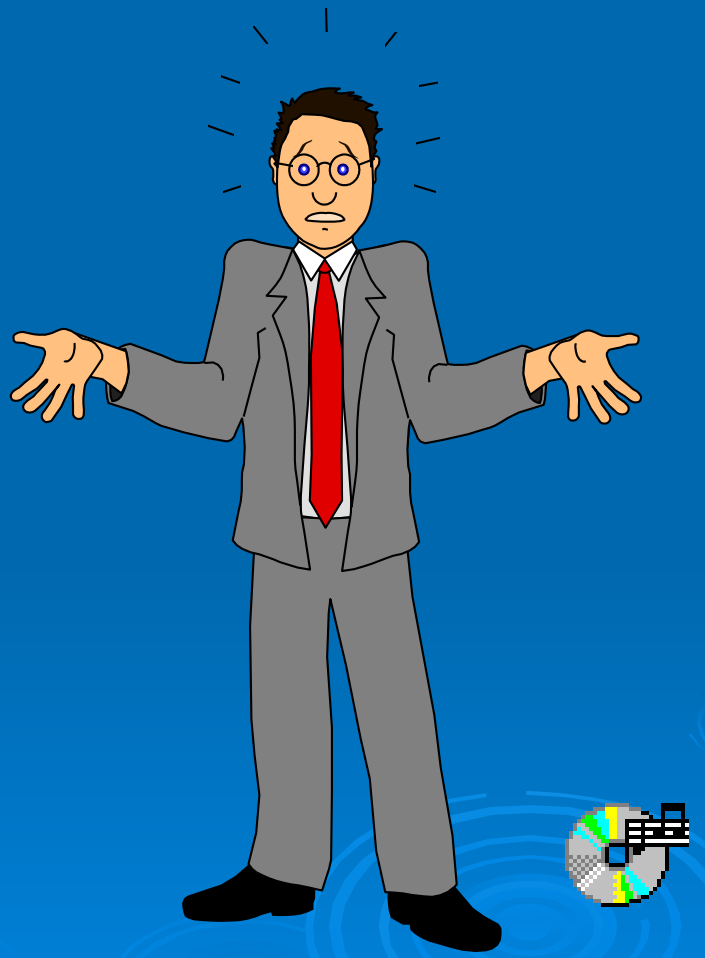
- Conductive hearing losses are due to problems that occur in the outer and middle ear which are usually temporary and/or treatable with antibiotics or surgery
- For those few people who have uncorrectable conductive hearing losses, hearing aids are of significant benefit as sound amplification is all that is needed.

SENSORI-NEURAL HEARING LOSSES

- Dysfunction of the inner ear or auditory nerve, usually **permanent** and untreatable; results in loudness deficit and distorted hearing.

SYMPTOMS:

- Inappropriate loud voice.
- Tinnitus
- High frequency loss
- Distorted speech sounds
- Difficulties with background noise
- Hearing aids may help



CAUSES OF SENSORI-NEURAL HEARING LOSS:

- Genetics/Congenital
- Disease
  - Mumps
  - meningitis
- Ototoxic drugs
- Head trauma
- Presbycusis
- Meniere's Disease
- Acoustic Neuroma
- **Noise Exposure**:
  - Prolonged exposure to hazardous noise causes hearing loss by the physical destruction of the hair cells of the cochlea.

HAZARDOUS NOISE EXPOSURE (cont.)

- Loss can be sudden (acoustic trauma) or gradual
- Amount of loss varies from person to person
- Classic symptoms:
  - Tinnitus
  - Generally affects the 3000-6000 Hz range
  - Bilateral and symmetrical
  - Difficulty understanding conversation
    - 90% of speech energy (power) is in the low frequencies. 90% of the information (meaning) is in the high frequencies.

TREATMENT:

- SENSORI-NEURAL HEARING LOSSES ARE DUE TO PROBLEMS THAT OCCUR IN THE INNER EAR AND ARE ALMOST ALWAYS PERMANENT AND UNTREATABLE.
- HEARING AIDS WILL BENEFIT MOST PEOPLE WITH SENSORI-NEURAL LOSS BUT RESULTS CAN VARY.

MIXED HEARING LOSS:

- Combination of conductive (outer or middle ear) disorder and sensori-neural hearing loss
- Treatment may be available for the conductive portion; however, the sensori-neural portion will remain.

NON-ORGANIC HEARING LOSS

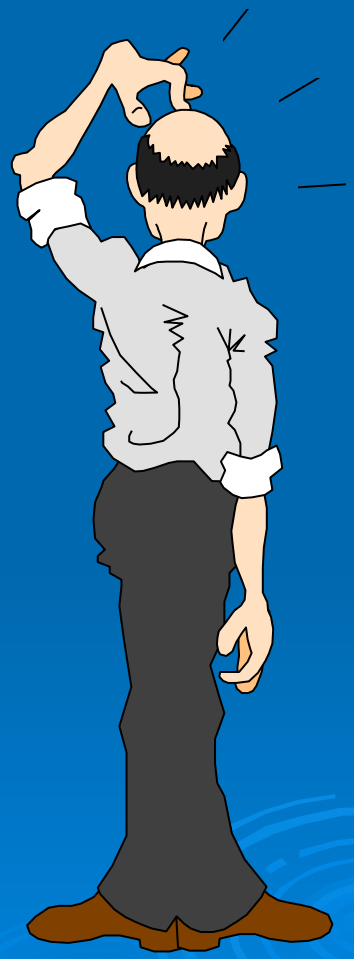
- *No medical or physical reason for hearing loss*
- *Malingering – conscious exaggeration of hearing impairment, may occur for monetary or other personal gain or to escape assignments or responsibilities*

1. Symptoms of malingering

- *Equal hearing loss at all frequencies or no response to pure tones at all in one or both ears*
- *Inconsistent test results*
- *Pushes on earphone during testing as if concentrating hard to hear*
- *Show no difficulty hearing you call them back for testing or to your directions (normal voice level is around 60 dB), can hear you when your back is turned or when no visual information is available*
- *Unconscious development of a non-organic hearing loss – a compensatory protective device, a psychogenic problem-- the patient believes the impairment is real*

CENTRAL HEARING LOSS

- Due to an auditory processing disorder in the central nervous system, often associated with other neurological disorders, sometimes confused with non-organic hearing loss due to patient's vague symptoms or inappropriate behavior; requires diagnostic work-up by an audiologist, otologist, and/or neurologist; patient usually presents with normal hearing.



IN SUMMARY….

- Conductive Hearing Loss = Low Frequency = Outer or Middle Ear = Temporary
- Sensorineural Hearing Loss = High Frequency = Inner Ear = Permanent
- Mixed Hearing Loss = High and Low Frequency = Outer or Middle and Inner Ear = Conductive portion of HL is treatable, Sensorineural portion is permanent
- Non-Organic Hearing Loss = Flat Loss Across All Frequencies or No Response at All Frequencies = Not a True HL, Exaggerated Hearing/Malingerer
- Central Hearing Loss = Normal Hearing Thresholds = Auditory Processing Problem from the Cochlea up the Brainstem to the Auditory Cortex

OTOSCOPIC EXAMINATION / HEARING PROTECTION FITTING PRACTICUM

OTOSCOPIC EXAMINATIONS

- **The evaluation of the ear canal and tympanic membrane through the use of an otoscope; an otoscope is a hand-held tool with a speculum and light source to see into the ear canal**

- **Purpose of the otoscopic exam is to ensure that the ear canals are free of any obvious problems prior to fitting hearing protection, performing tympanometry or administering hearing tests**

OTOSCOPIC EXAMINATIONS (Cont.)

- Otoscope Check
  - **Otoscope light should be bright white**
  - **Use rheostat to adjust light intensity**

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ery is prope

OTOSCOPIC EXAMINATIONS (Cont.)

- Preparation for Otoscopic Exam
  - Select speculum according to size of ear; the larger the speculum, the better the view
  - Lock speculum into place
  - Change speculum between each patient
  - Change speculum between each ear of patients with draining ears

OTOSCOPIC EXAMINATIONS (Cont.)

- Examination Method
  - **Grip the otoscope firmly and comfortably**
  - **With the opposite hand, grasp the helix of the ear and gently pull the pinna upward and back to straighten the ear canal**
  - **Gently insert the lighted otoscope past the first canal bend, resting your fingers against the patient's head; if the patient turns or moves suddenly, the otoscope will move in unison with the patient's head avoiding injury**
  - **After the otoscope is in place, put your eye up to the otoscope eyepiece and examine the ear canal and tympanic membrane**
  - **Only a portion of the membrane will be visible at one time, you must move the otoscope around to obtain a composite view of the entire tympanic membrane**

OTOSCOPIC EXAMINATIONS (Cont.)

- What to look for:
  - Clear canals free of any obvious problems, such as, discharge, impacted cerumen, masses, inflammation, foreign bodies
  - Tympanic membrane landmarks
    - **Cone of light spreading from the center of tympanic membrane outward to the edge of the membrane**
    - **Lower end of the manubrium of the malleus protruding at the center of the eardrum**

Normal Findings:

- **Canals clear of any obvious problems, appearance of some cerumen is a normal finding, however, cerumen should not be occluding more than 25% of ear canal**
- **Color of eardrum should be pearly gray and translucent in appearance**

Photo's courtesy of Dr. Roy F. Sullivan, Ph.D.

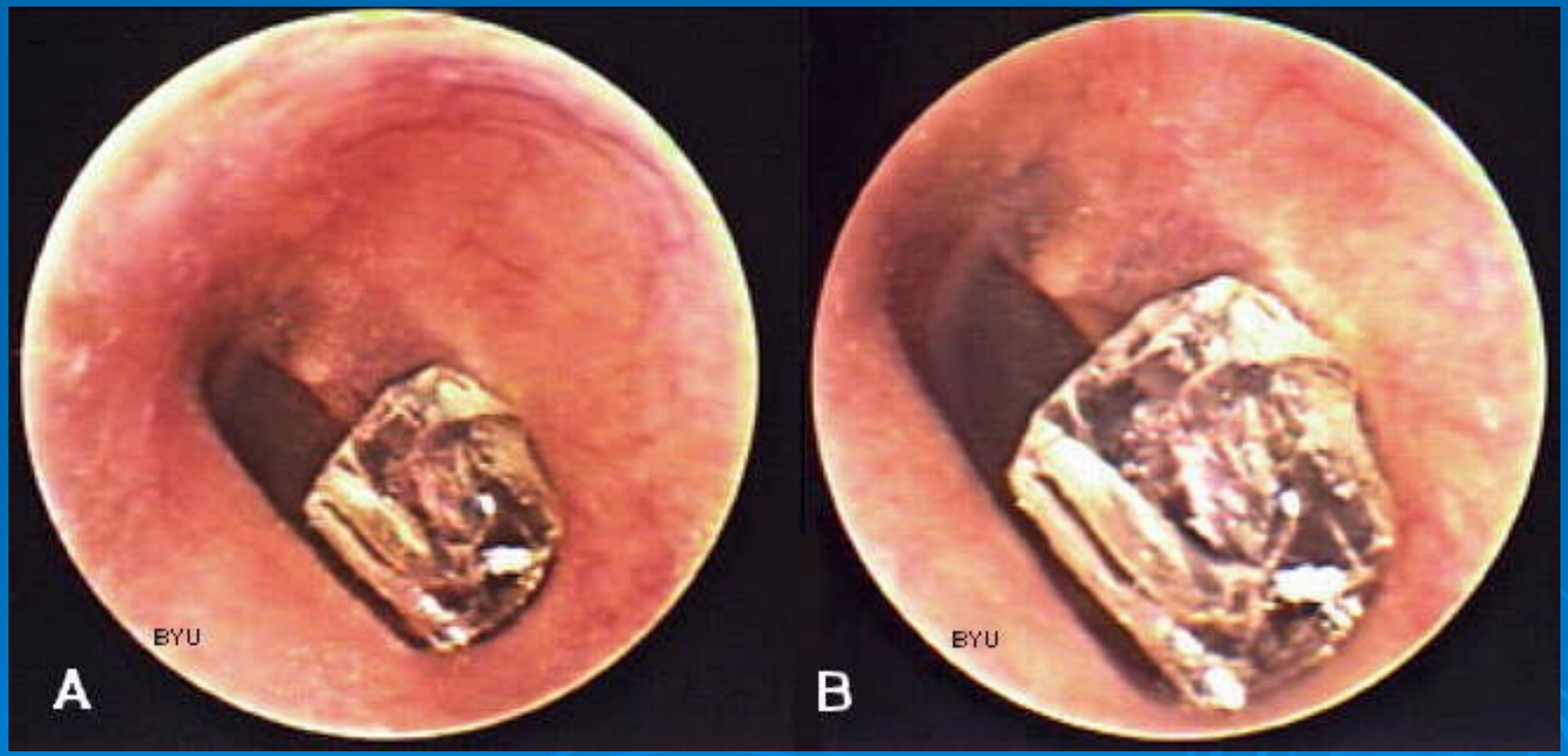
ABNORMAL FINDINGS: EAR CANAL

CERUMEN

- Excessive Cerumen:
  - If you can’t see at least half of the ear canal, then a cleaning is recommended.

Photo’s courtesy of Dr. Roy F. Sullivan, Ph.D.

Foreign Bodies:

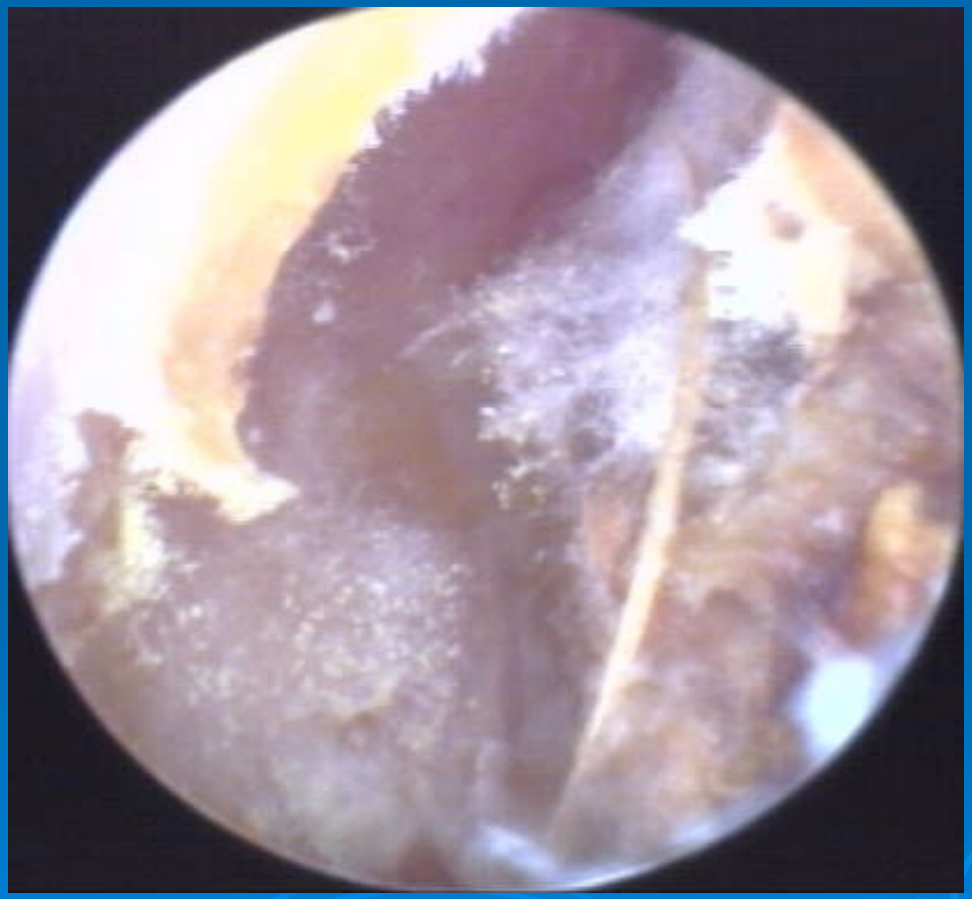


Photo's courtesy of Dr. Roy F. Sullivan, Ph.D.

Insect On Ear Canal Wall

Photo's courtesy of Dr. Roy F. Sullivan, Ph.D.

Cotton Swab Residue

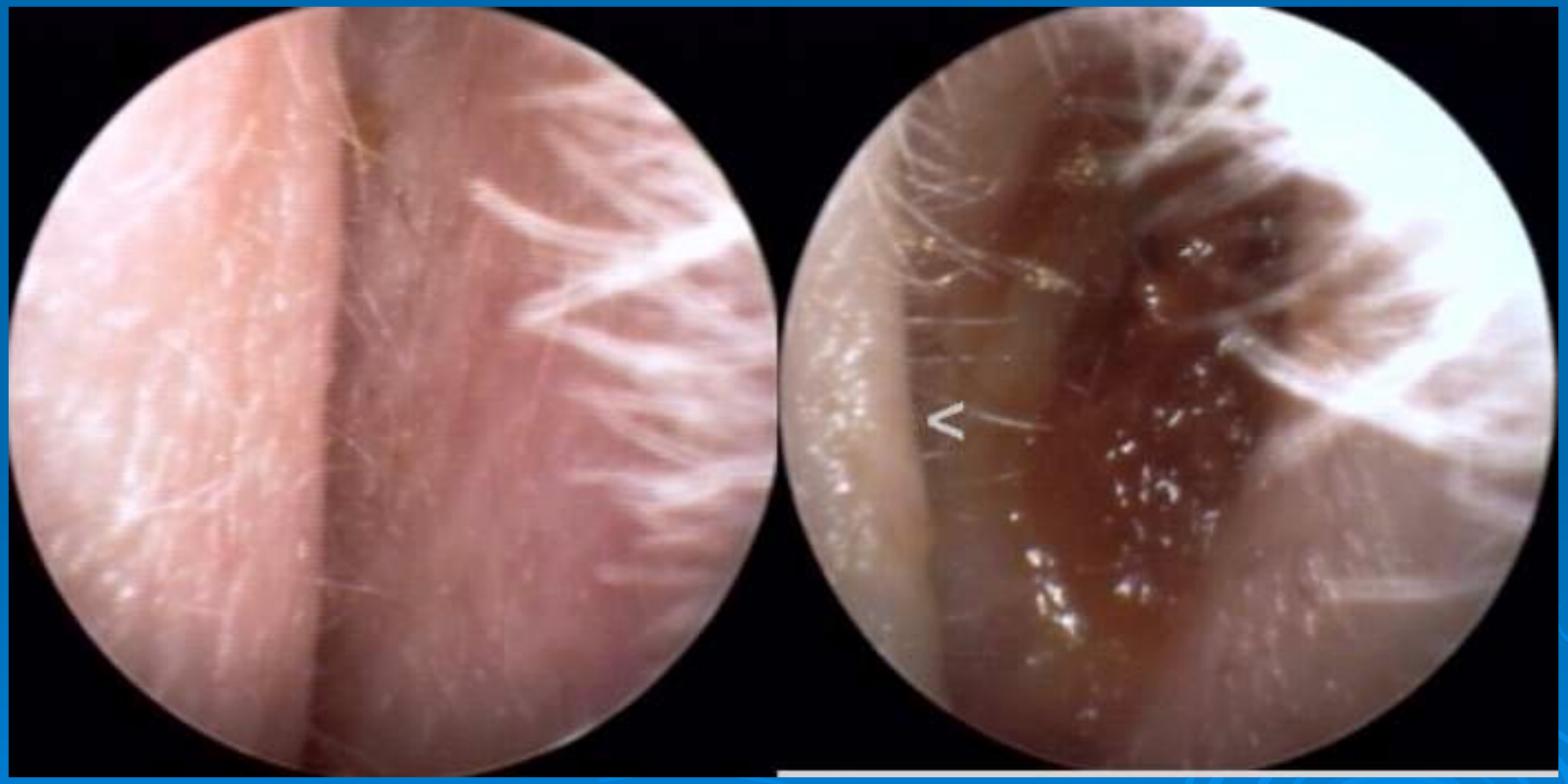


Photo's courtesy of Dr. Roy F. Sullivan, Ph.D.

Earplug, 1 Year After Rock Concert…

Photo's courtesy of Dr. Roy F. Sullivan, Ph.D.

Collapsing Canals:



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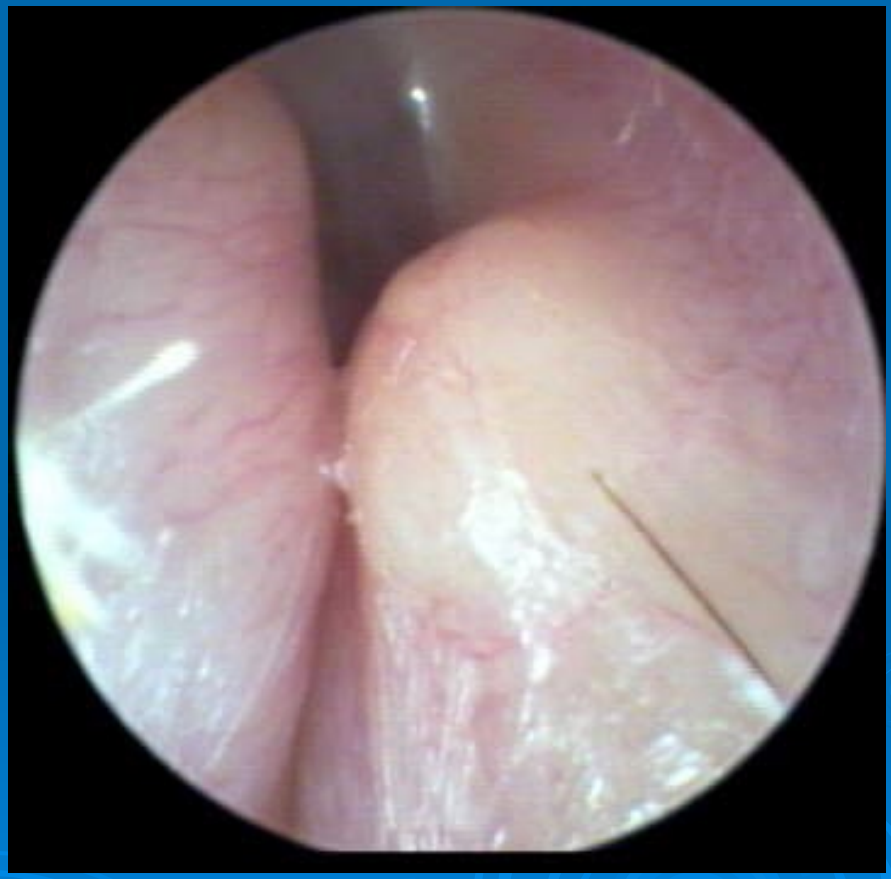
Exostosis:



Bony growth in canal (will not affect hearing test results unless it occludes the ear canal)

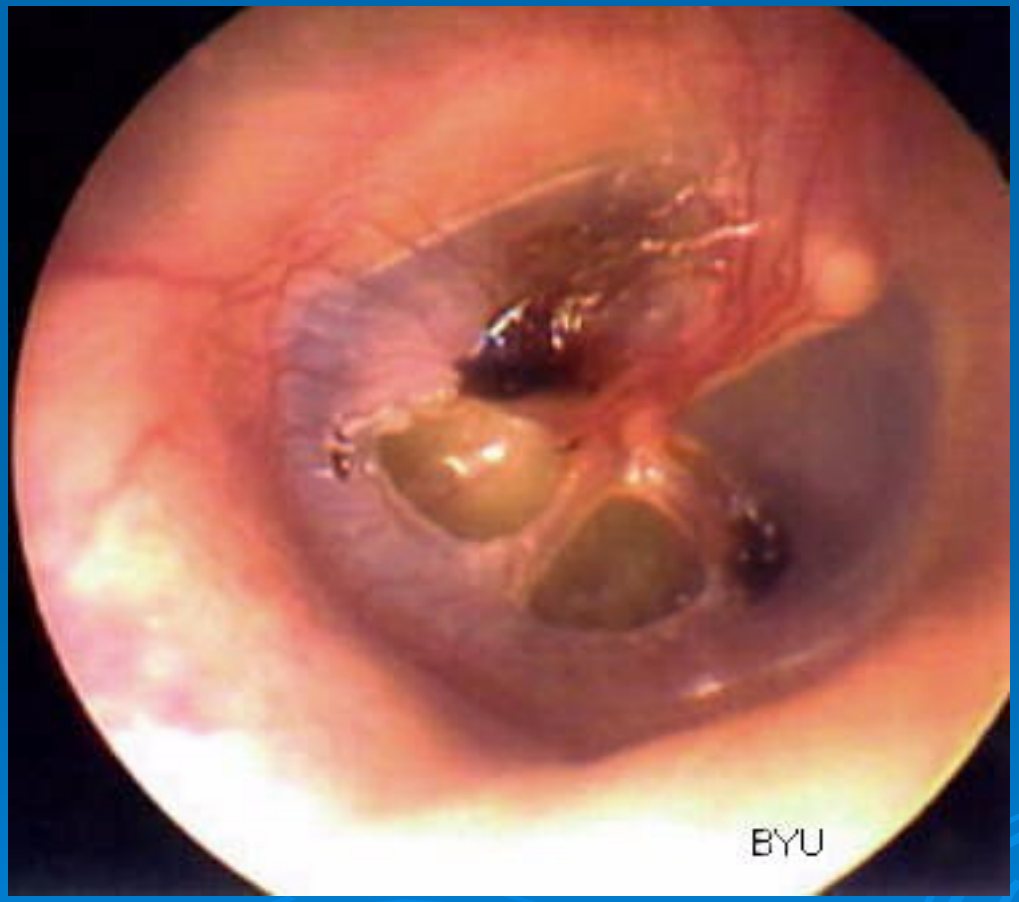
Photo's courtesy of Dr. Roy F. Sullivan, Ph.D.

ABNORMAL FINDINGS: TYMPANIC MEMBRANE

TM Perforations:

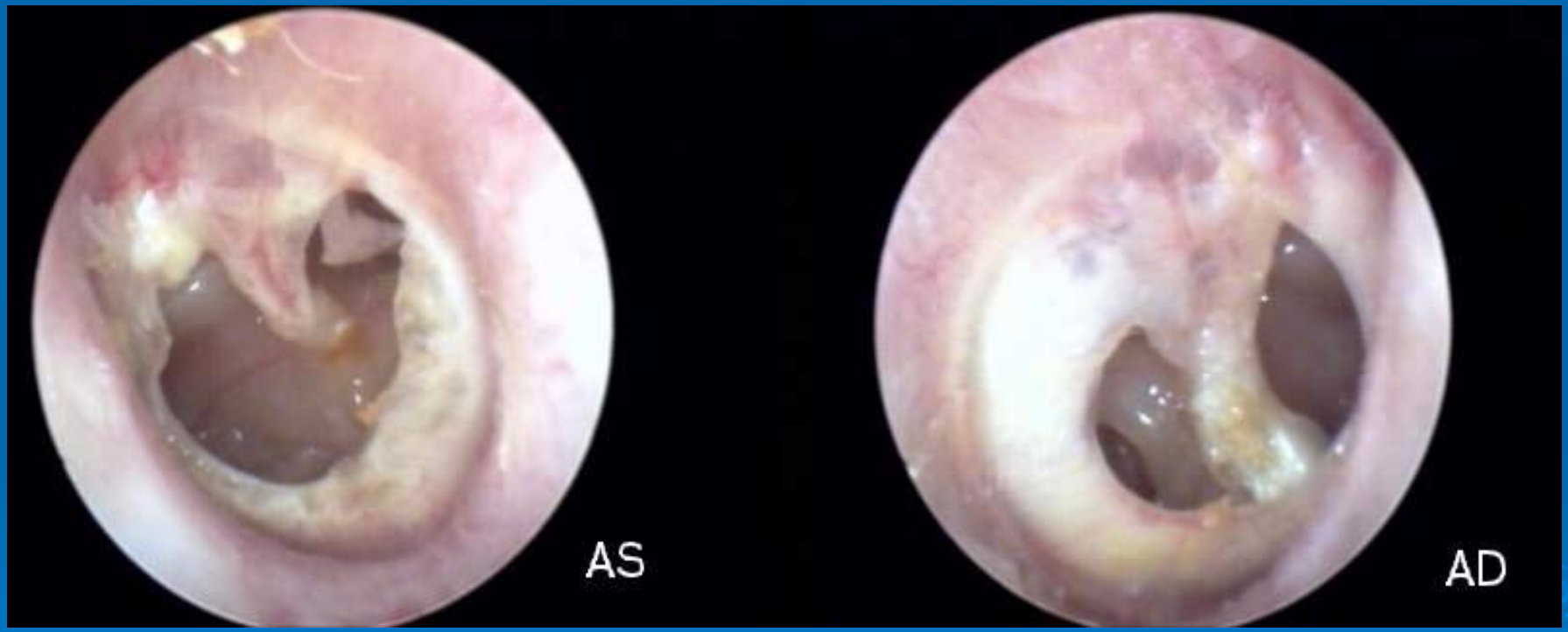
Photo's courtesy of Dr. Roy F. Sullivan, Ph.D.

Perforation’s (cont.)



Photo’s courtesy of Dr. Roy F. Sullivan, Ph.D.

Perforations #3



Photo's courtesy of Dr. Roy F. Sullivan, Ph.D.

Otitis Media

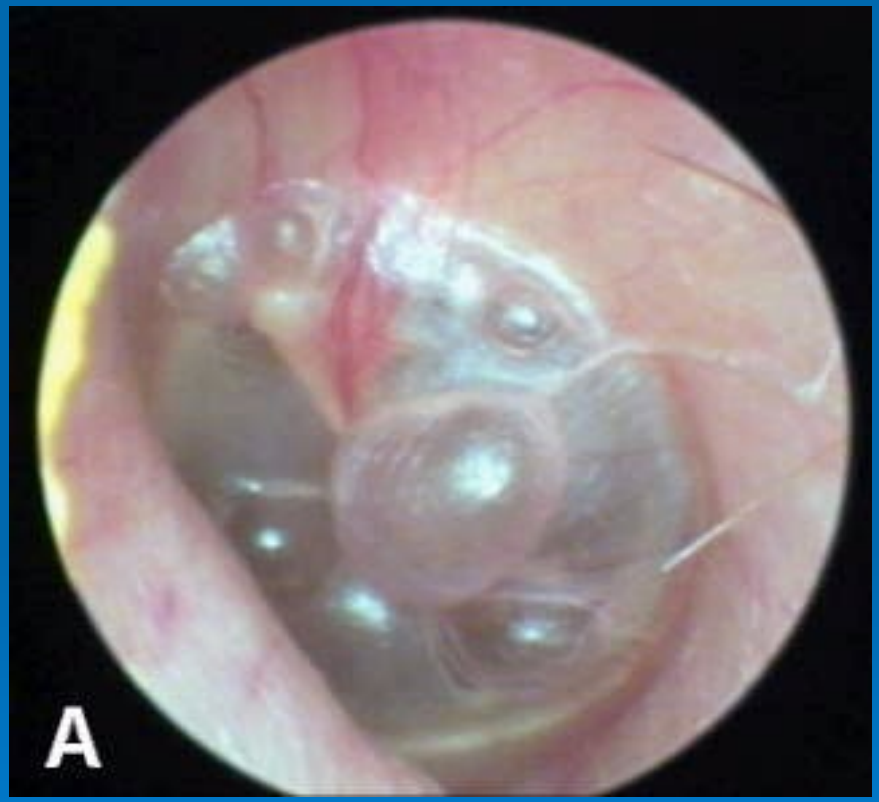
Photo's courtesy of Dr. Roy F. Sullivan, Ph.D.

Retracted Eardrum

Photo's courtesy of Dr. Roy F. Sullivan, Ph.D.

- ***Suggests Eustachian Tube Dysfunction (negative middle ear pressure)***
- ***Middle ear ossicles may stand out boldly as tympanic membrane is stretched tightly over them***
- ***Increase in vascularity of the tympanic membrane blood vessels***
- ***Valsalva maneuver may cause an increase in***

Bulging Eardrum



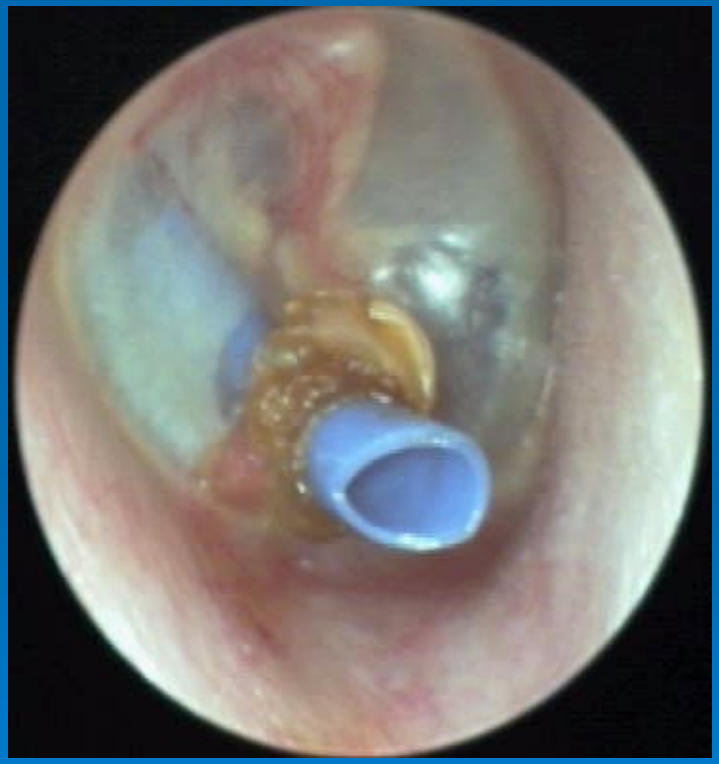
. Occurs when membrane is forced outward by excessive pressure or fluid build up

. Landmarks may be absent

. Tympanic membrane in red or brown in color

Photo's courtesy of Dr. Roy F. Sullivan, Ph.D.

Ventilation Tubes



. Surgically implanted in tympanic membrane to ventilate middle ear cavity

. Varies in color: blue, white, green, silver

Do not disturb

Photo's courtesy of Dr. Roy F. Sullivan, Ph.D.

Cholesteatoma

Cystic mass that usually grows from a marginal perforation in the superior region of the tympanic membrane
Very erosive and life threatening if not addressed

Tympanosclerosis

. Chalky or white appearance of tympanic membrane due to previous or repeated infections

. Usually benign

Photo's courtesy of Dr. Roy F. Sullivan, Ph.D.

When to do an Otoscopic Examination

- Before a reference audiogram
- Before testing, if patient complains of an ENT problem
- Before tympanometry
- Before earplug fitting
- When an STS is discovered
- When a low frequency or flat hearing loss is detected

Referral to Medical Officer when…

- Pain or discomfort is reported
- Drainage is visible
- Perforation is visible
- Tympanic membrane is bulging
- Ear canal is blocked by cerumen or foreign body
- When in doubt

QUESTIONS???